SHORT COMMUNICATIONS

A NEW FORMULA FOR SPHERICAL MIRRORS AND THIN LENSES

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THIS note shows the existence of a hitherto unreported formula relating the focal length (f) of a spherical mirror in the form $f = (AB)/(A-B)$ where A and B are the distances of the object and image respectively, measured from the centre of curvature of the mirror. The formula and the related magnification formulas are derived from the ray diagrams. Similar formula for lenses will hold, if A and B are measured from object and image respectively, to the point, distant $2f$ from the vortex on the principal axis on the object and image sides. A literature search does not show such studies in the past. Simple calculations give the expression for the magnification (m) to be

$$m = -B/A = (B-f)/f = -f/(A+f).$$

The derivation and use of these formulas can be contrasted with the commonly known Gaussian or Descartes' form, $1/f = 1/p + 1/q$, where p and q are the object and image distances measured respectively from the vortex of the mirror; and Newton's form $ab = f^2$, wherein the object and image distances a and b are measured respectively from the focus of the mirror. The new formula can be used to supplement the conventional ray tracing lecture and laboratory exercises in general physics course. It is expected to hold well for both thin and thick lenses.

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SYNTHESIS OF SOME NEW 3-CYCLOHEXYLTHIOSEMICARBAZONO-2-INDOLINONES AS ANTIBACTERIAL AGENTS

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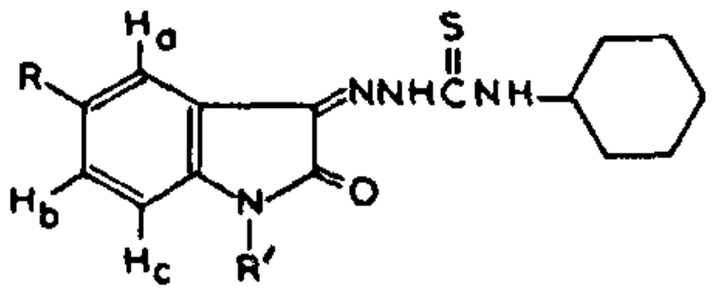
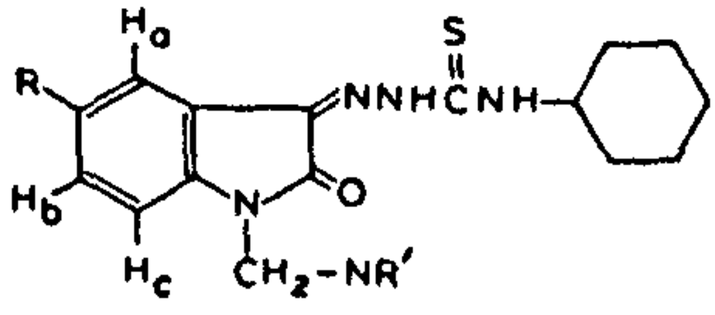
ISATINS and 1-methyl isatins on condensation with cyclohexylthiosemicarbazide afford 3-cyclohexylthiosemicarbazono-2-indolinones(I) and 1-methyl-3-cyclohexylthiosemicarbazono-2-indolinones(II), respectively. Compounds (I) have also been synthesized by amine-exchange reaction of 3-cyclohexylimino-2-indolinones with cyclohexylthiosemicarbazide. Compound I (R = H) on heating with formalin and water furnishes 1-hydroxymethyl-3-cyclohexylthiosemicarbazono-2- indolinone (III). When compounds (I) are subjected to Mannich reaction, 1-substituted aminomethyl-3-cyclohexylthiosemicarbazono-2-indolinones (IV) are obtained. Compound IV_a has also been synthesized by the reaction of compound III with morpholine in ethanol. Compounds (IV) have been screened against *Bacillus subtilis* and *Staphylococcus aureus* for their antibacterial action. Many of these compounds show significant inhibition.

Several analogs of isatin have been reported to be associated with diverse biological activities including antibacterial[1,2], antifungal[3], antiviral[4,5], cysticidal[6] and anthelmintic[7] activities. Further, reports pertaining to the bactericidal, fungicidal and virucidal properties of thiosemicarbazides[8,9] and Mannich bases[10,11] of isatins are available. These observations prompted the author to undertake the synthesis of 3-cyclohexylthiosemicarbazono-2-indolinones (I) and their 1-methyl-(II) and 1-substituted aminomethyl-(IV) derivatives incorporating isatin as well as thiosemicarbazide moieties. Compounds (IV) were screened against two bacteria viz. *Bacillus subtilis* and *Staphylococcus aureus* to find out their usefulness as antibacterial agents.

Isatins, the starting material for compounds I–IV, were prepared by making use of Sandmeyer reaction.



I, R′ = H
II, R′ = CH_3
III, R′ = CH_2OH



IV

Cyclohexylthiosemicarbazide was prepared by treating cyclohexylamine with carbon disulphide in ammonical solution followed by the addition of sodium chloroacetate and hydrazine hydrate[12]. Condensation of isatins with cyclohexylthiosemicarbazide in equimolar proportions in ethanol under acidic medium resulted in the synthesis of 3-cyclohexylthiosemicarbazono-2-indolinones (I). Compounds (I) were also obtained by refluxing 3-cyclohexylimino-2-indolinones with cyclohexylthiosemicarbazide. Identity of the products synthesized by both the methods was checked by TLC, m.p., mixed m.p. and IR. Isatins on reaction with dimethylsulphate in ethanolic potassium hydroxide afforded 1-methylisatins, which on condensation with cyclohexylthiosemicarbazide in acidic medium furnished 1-methyl-3-cyclohexylthiosemicarbazono-2-indolinones (II). Compound I (R = H) on heating with formalin and water furnished 1-hydroxymethyl-3-cyclohexylthiosemicarbazono-2-indolinone (III). Mannich condensation of I with formalin and secondary amines in ethanol yielded 1-substituted aminomethyl-3-cyclohexylthiosemicarbazono-2-indolinones (IV). Compound IV_a (NR′ = morpholino) was also synthesized by the reaction of III with morpholine in ethanol. This compound was identical with the compound synthesized by Mannich reaction. Structures of all the compounds were established on the basis of their elemental analyses and spectral (IR & PMR) data.

Antibacterial activity

All 1-substituted aminomethyl-3-cyclohexylthiosemicarbazono-2-indolinones (IV) were evaluated for their inhibitory effects *in vitro* against *B. subtilis* and *S. aureus* according to the method of Varma and Nobles[13].

The results (table 1) indicate that all the compounds except IV_c and IV_e inhibit the growth of *B. subtilis* and except IV_c and IV_f that of *S. aureus* also. Compound IV_l shows maximum significant inhibition (zone size 23 mm) against *B. subtilis* and IV_r against *S. aureus* (zone size 22 mm). The results of antibacterial activity reveal that in compounds with NR′ = piperidino, pyrrolidino and 4-(4′-chlorophenyl)-1-piperazino, the substitution of (R = H) by R = CH_3 or Cl has an increasing influence on the activity against *B. subtilis* and vice versa in those

Table 1 *Characteristic and antibacterial data of compound IV*

Compound No.	R	NR′	m.p. °C	Molecular formula	N(%) Calc.	N(%) Found	Antibacterial activity* *B. subtilis*	Antibacterial activity* *S. aureus*
IV_a	H	Morpholino	192	$C_{20}H_{27}N_5O_2S$	17.4	17.2	d	b
IV_b	H	Piperidino	103–04	$C_{21}H_{29}N_5OS$	17.5	17.4	a	b
IV_c	H	Pyrrolidino	127	$C_{20}H_{27}N_5OS$	18.2	17.9	–	a
IV_d	H	4-Me-1-piperazino	165	$C_{21}H_{30}N_6OS$	20.3	20.4	a	b
IV_e	H	4-Ph-1-piperazino	178–79	$C_{26}H_{32}N_6OS$	17.6	17.3	–	–
IV_f	H	4-(4′-Chlorophenyl) -1-piperazino	176	$C_{26}H_{31}ClN_6OS$	16.4	16.7	b	–
IV_g	CH_3	Morpholino	140	$C_{21}H_{29}N_5O_2S$	16.9	16.7	a	a
IV_h	CH_3	Piperidino	179	$C_{22}H_{31}N_5OS$	16.9	17.2	b	a
IV_i	CH_3	Pyrrolidino	232	$C_{21}H_{29}N_5OS$	17.5	17.3	d	c
IV_j	CH_3	4-Me-1-piperazino	157	$C_{22}H_{32}N_6OS$	19.6	19.5	a	d
IV_k	CH_3	4-Ph-1-piperazino	178	$C_{27}H_{34}N_6OS$	17.1	17.0	c	a
IV_l	CH_3	4-(4′-Chlorophenyl) -1-piperazino	192	$C_{27}H_{33}ClN_6OS$	16 0	15.8	d	d
IV_m	Cl	Morpholino	156	$C_{20}H_{26}ClN_5O_2S$	16.1	15 9	a	a
IV_n	Cl	Piperidino	159	$C_{21}H_{28}ClN_5OS$	16.1	16.3	c	a
IV_o	Cl	Pyrrolidino	149–50	$C_{20}H_{26}ClN_5OS$	16.7	16.8	b	c
IV_p	Cl	4-Me-1-piperazino	161	$C_{21}H_{29}ClN_6OS$	18.7	18.5	a	c
IV_q	Cl	4-Ph-1-piperazino	181	$C_{26}H_{31}ClN_6OS$	16.4	16.3	a	b
IV_r	Cl	4-(4′-Chlorophenyl) -1-piperazino	199	$C_{26}H_{30}Cl_2N_6OS$	15.4	15.2	d	d

– = No inhibition; a = Zone size 6–10 mm; b = Zone size 11–15 mm; c = Zone size 16–20 mm; d = Zone size 20–25 mm.

having NR′ = morpholino. Compounds IV_d, IV_j and IV_p with R = H, CH_3 and Cl, respectively, and NR′ = 4-methyl-1-piperazino group have shown only moderate activity against the organism.

Regarding the effect of different substituents on antibacterial activity against *S. aureus*, one can infer that substitution of R = H by R = CH_3 or Cl has increased the activity of the compounds having NR′ = pyrrolidino, 4-methyl-1-piperazino, 4-phenyl-1-piperazino, 4-(4′-chlorophenyl)-1-piperazino and vice versa in those with NR′ = morpholino and piperidino.

Experimental procedure

Melting points were determined in open capillary tubes using sulphuric acid-bath and are uncorrected. IR spectra in KBr were recorded on a Perkin-Elmer 157 infracord spectrophotometer (ν_{max} in cm^{-1}) and PMR spectra in $CDCl_3$ on a Varian A-60 MHz instrument using TMS as the internal reference (chemical shifts in δ ppm). The purity of the compounds was checked on TLC.

5-Methyl-3-cyclohexylthiosemicarbazono-2-indolinone (I, R = CH_3): Method A

A mixture of 5-methylisatin (1.61 g, 0.01 mol) and cyclohexylthiosemicarbazide (1.98 g, 0.01 mol) in 25 ml of ethanol containing two drops of glacial acetic acid was refluxed on a water bath for 2 h. The solid, which separated out on cooling, was filtered and recrystallized from ethanol, m.p. 243°; yield 80% (Found: C, 60.93; H, 6.10; N, 17.64 $C_{16}H_{20}N_4OS$ requires C, 60.76; H, 6.33; N, 17.72%); IR : 3300 (NH, indole), 3100 (NH), 2880 and 2810 (CH), 1675 (C = O), 1615 (C = N), 1150 (C = S). PMR ($CdCl_3$) spectrum displayed the signals at 1.02–2.18 (*m*, 11H, CH_2, C*H*), 2.26 (*s*, 3H, CH_3), 6.82 (*q*, J = 9.5 and $1H_z$, 1H, H_b), 7.28 (*d*, J = $1H_z$, 1H, H_a), 7.56 (*d*, J = $4.5H_z$, 1H, H_c).

The following two compounds were also synthesized by the above method:

3-Cyclohexylthiosemicarbazono-2-indolinone (I, R = H): m.p. 219°, yield 75% (Found N, 18.25 $C_{15}H_{18}N_4OS$ requires N, 18.54%); IR: 3250 (NH, indole), 3100 (NH), 2875 and 2820 (CH), 1678 (C = O), 1610 (C = N), 1185 (C = S). 5-Chloro-3-cyclohexylthiosemicarbazono-2-indolinone (I, R = Cl): m.p. 255°, yield 70% (Found N, 16.49 $C_{15}H_{17}ClN_4OS$ requires N, 16.64); IR: 3320 (NH, indole), 3200 (NH), 2900 and 2835 (CH), 1685 (C = O), 1615 (C = N), 1150 (C = S).

Method B

Compounds(I) were also prepared by the method of amine-exchange reaction of 3-cyclohexylimino-2-indolinones with cyclohexylthiosemicarbazide as below.

A mixture of 0.005 mol of an appropriate 3-cyclohexylimino-2-indolinone and 0.005 mol of cyclohexylthiosemicarbazide was refluxed with 20 ml ethanol containing two drops of glacial acetic acid for 4 h. The reaction mixture was then cooled and the separated solid was filtered and recrystallized from ethanal.

Identity of the products synthesized by the methods A & B was confirmed by mixed m.p., IR and TLC.

1-Methyl-5-chloro-3-cyclohexylthiosemicarbazono-2-indolinone (II, R = Cl)

This was prepared by heating 0.01 mol of 1-methyl-5-chloroisatin with 0.01 mol of cyclohexylthiosemicarbazide in 25 ml of ethanol containing two drops of glacial acetic acid for 4 h under reflux. The reaction mixture was cooled and the separated solid was filtered and recrystallized from ethylacetate, m.p. 232°, yield 65% (Found N, 15.74 $C_{16}H_{19}ClN_4OS$ requires N 15.98%); IR : 3340 (NH), 2980 & 2910 (CH), 1710 (C = O), 1630 (C = N), 1185 (C = S). PMR ($CdCl_3$) spectrum exhibited signals at 1.07–2.30 (*m*, 11H, CH_2, C*H*), 3.12 (*s*, 3H, CH_3), 6.68 (*d*, J = $4.5H_z$, lH, H_c), 7.02 (*q*, J = 8 & 1.5 H_z, lH, H_b), 7.44 (*d*, J = 1.5 H_z, lH, *H*a).

The following two compounds were also prepared by the above method:

1 -Methyl-3-cyclohexylthiosemicarbazono-2-indolinone (II, R=H): m.p. 211°, yield 60% (Found N, 17.55 $C_{16}H_{20}N_4OS$ requires N, 17.72%); IR: 3280 (NH), 2930 & 2860 (CH), 1685 (C = O), 1610 (C = N), 1180 (C = S).

1, 5-Dimethyl-3-cyclohexylthiosemicarbazono-2-indolinone (II, R = CH_3): m.p. 278°, yield 65% (Found N, 17.12 $C_{17}H_{22}N_4OS$ requires N, 16.97%); IR: 3350 (NH), 2980 & 2925 (CH), 1710 (C = O), 1645 (C = N), 1190 (C = S).

1-Hydroxymethyl-3-cyclohexylthiosemicarbazono-2-indolinone (III, R = H):

A mixture of 3-cyclohexylthiosemicarbazono-2-indolinone (*I*, R = H; 1.5 g) and formalin (37%, 2.5 ml) in water (15 ml) was refluxed on a sand bath for 1 h. The product obtained after allowing the reaction mixture to remain at room temperature

overnight, was filtered and recrystallized from methanol, m p. 118–20°, yield 50%, Found N, 15.92; $C_{16}H_{20}N_4O_2S$ requires N, 16.18%,. IR: 3480 (OH), 3240 (NH), 2970 & 2875 (CH), 1725 (C = O), 1625 (C = N), 1180 (C = S).

1-Substituted aminomethyl-3-cyclohexylthiosemicarbazono-2-indolinones (IV):

Method A

An appropriate 3-cyclohexylthiosemicarbazono-2-indolinone (I, 0.005 mol) was suspended in 10 ml of warm ethanol. To this suspension was added 1 ml of 37% formalin and an appropriate secondary amine (0.005 mol) with vigorous stirring. This mixture was then heated on a water bath for 10 min and allowed to remain at room temperature overnight. The separated solid product was filtered, washed with petroleum ether (b.p. 60–80°) and finally recrystallized from ethylacetate/chloroform-petroleum ether (b.p. 60–80°). All compounds (iV) thus synthesized are listed in table 1, yield 55–70%. Their IR spectra showed characteristic absorption bands at 3300–3225 (NH), 2900–2870 and 2825–2800 (CH), 1685–1670 (C = O), 1615–1600 (C = N), 1185–1150 (C = S). PMR ($CdCl_3$) of IV_g: 1.13–2.30 (*m*, 11H, CH_2, *CH*), 2.38 (*s*, 3H, CH_3), 2.47–2.74 (*m*, 4H, CH_2-N-CH_2), 3.54–3.84 (*m*, 4H, CH_2-O-CH_2), 4.45 (*s*, 2H, N-CH_2-N), 7.05 (*q*, J=9 & 1.5 Hz, 1H, H_b), 7.40 (*d*, J=1Hz, 1H, *H*a), 7.64 (*d*, J = 6.5 Hz, 1H, *H*c); PMR ($CdCl_3$) of IV_j: 1.17–2.07 (*m*, 11H, CH_2, *CH*), 2.14 (*s*, 3H, Ar-CH_3), 2.25 (*s*, 3H, N-CH_3), 2.26–2.65 (*m*, 8H, CH_2-N-CH_2), 4.36 (*s*, 2H, N-CH_2-N), 6.88 (*q*, J = 9 & 1.5 Hz, 1H, *H*b), 7.30 (*d*, J = 1 Hz, 1H, *H*a), 7.55 (*d*, J = 4.5 Hz, 1H, H_c); PMR ($CdCl_3$) of IV_n: 1.02–2.30 (*m*, 17H, *CH*, *CH*), 2.37–2.74 (*m*, 4H, CH_2-N-CH_2), 4.43 (*s*, 2H, N-CH_2-N), 6.97 (*d*, J = 7.5 Hz, 1H, *H*c), 7.31 (*q*, J = 9 & 1.5 Hz, 1H, *H*b), 7.52 (*d*, J = 2 Hz, 1H, *H*a).

Method B

1-Morpholinomethyl- 3 -cyclohexylthiosemicarbazono-2-indolinone (IVa), prepared according to the method A, was also prepared by heating a mixture of 1-hydroxymethyl-3-cyclohexylthiosemicarbazono-2-indolinone (III, 0.005 mol) and morpholine (0.005 mol) in 10 ml ethanol, on a water bath for 10 min. The mixture was stirred vigorously and allowed to stand overnight. The separated solid was filtered, washed with petroleum ether (b.p. 60–80°) and recrystallized from ethylacetate. This compound was identical with the compound IVa synthesized by method A. PMR ($CdCl_3$) spectrum of this compound exhibited signals at 1.10–2.24 (*m*, 11H, CH_2, *CH*), 2.36–2.67 (*m*, 4H, CH_2-N-CH_2), 3.38–3.74 (*m*, 4H, CH_2-O-CH_2), 4.36 (*s*, 2H, N-CH_2-N), 6.94–7.68 (*m*, 4*H*, Ar-*H*).

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KINETICS OF POLYMERIZATION OF ACRYLAMIDE INITIATED BY Mn^{3+}- L-THREONINE REDOX SYSTEM

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MANGANESE (III) salts in combination with a variety of reducing agents such as diglycolic acid[1], isobutyric